NOTES FOR STUDENTS.

IN SEARCH of an explanation for mycorhiza Dr. E. Stahl has made a comparative study of broader scope than any involved in the previous researches upon the subject.[7] The interesting conclusion of extended observations upon the distribution of mycorhiza is that, hydrophytes aside, the large majority of vascular plants possess it. Its occurrence, in the words of the author, "has an intimate relation with increased difficulties of nutrition."

That photosynthesis is so intimately conditioned by transpiration as to be approximately in direct proportion to it is a fundamental premise of Stahl's conception. Further, it is assumed as demonstrated that the host, in the presence of mycorhiza, possesses a nutritive advantage. Now if it be found that mycorhiza is coincident with low transpiration, may not the nutritive advantage of the former provide a certain compensation for the weakness of the latter? Indeed the author seeks to refer the inception of mycorhiza to comparative weakness of absorption as an original cause. For, he argues, a root system unable to supply the green parts with a transpiration stream carrying nutrient salts commensurate with the demand would at once induce a need for equivalence of organic substances which it is the function of the mycorhiza habit to supply. Holding with Frank that the humus soil of forests is in large part "a living mass of innumerable fungal hyphæ," the discussion of competition for nutrient salts upon forest floors leads to the conclusion that, unless possessed of root-systems of exceptional absorbent efficiency, the vascular green plant is placed at decided disadvantage; this notwithstanding the great and apparently available store of nutritive material, and on account of the ubiquity and chemotropic advantage of the rival fungal hyphæ. The obligate mycorhiza plants with low transpiration cannot, it is argued, independently compete for nutrient salts with vascular plants of high transpiration or with the fungi, but they escape the stress of that competition by making tributary to themselves certain fungi from which they supplement the supply of elaborated organic compounds. That holosaprophytism involves no more than increased reliance upon the fungal tributaries and corresponding loss of even potential photosynthesis is obvious. Stahl attributes the inception of the parasitic and carnivorous habits to the same handicap in competition for the nutrient salts. There should be noted herein a certain parallelism of argument with the claim of Frank for definition of endotrophic mycorhiza as "fungus-traps," although Stahl does not agree with Frank in holding to a different physiological significance between the ectotropic and endotropic forms.

It is quite unlikely that the author will escape criticism for the breadth of certain of his generalizations or for his use of certain facts as positive

[7] STAHL, E.: Der Sinn der Mycorhizenbildung. Jahrb. f. wiss. Bot. **34**: 539–668. 1900.

criteria when an interpretation totally at variance from that upon which his conclusions depend is at least admissible. Thus at the very outset he devotes a number of pages to the discussion of "criteria for the relative water-demand of plants." He seeks a ready means of determining in extended observations whether or not mycorhiza when present is associated with reduced transpiration, as his hypothesis demands. The presence of starch rather than sugar in the leaves is selected as the foremost characteristic for his purposes indicative of greater transpiratory activity. "For," he writes, "the advantage of starch formation lies very largely in the promotion thereby of transpiration, since reduced concentration stimulates the evaporation rate; and, inversely, an increase of the dissolved substances, glucose, for example, must have a retarding effect." But it is a fair question whether starch may not appear only after a maximum concentration has been attained, and hence its absence regarded as favorable rather than opposed to transpiration.

Certain experiments upon *Sinapis alba*, *Linum usitatissimum*, and *Triticum vulgare*, forms free of any trace of mycorhiza, are of interest in affording striking contrast with Frank's experiments upon beech and pine seedlings. In the latter case, as is well known, the development in a sterilized soil of seedlings normally possessed of mycorhiza was strikingly deficient in contrast with individual plants in unaltered humus soil. But, if the contention of Stahl is sustained, autotrophic forms should flourish in especial degree in soil where they are freed of the rivalry of fungi, which unlike their more specialized mycotrophic kin, they are unable to make tributary; *i. e.*, exactly the reverse of the results with mycotrophic forms. And such is found to be the case in striking degree. Incidentally, however, an excursion is made to demonstrate the retarding effect of abundance of nutrient salts upon root growth. For, though the shoot is feeble, the root system, as is reasonable to expect, becomes more elongated in the autotrophic forms grown in competition with the fungi.

That part of the paper which deals with "the absorption of nutrient salts and the ash-content of mycotrophic as compared with autotrophic plants" is none the less important in that it seems to belong as a closing chapter to such special studies of this subject as those of MacDougal and Groom rather than to a contribution so broadly comparative in character as this one. The introductory argument that the ash content of mycotrophic plants should have certain specific differences from that of autotrophic forms is more safely founded upon the previous and detailed study of others, than upon a general association of mycorhiza with forms limited in their possibilities of independent food-elaboration, however broad and striking that association may be. Suffice it for the argument that his examples show a certain parallelism to exist between a greater ash-content and autotrophy on the one hand, and less ash-content and mycotrophy on the other. This tends to

confirm the idea that mycotrophic plants receive from the fungi certain necessary mineral substances already in the form of organized compounds, for thereby they would be relieved to that extent of the necessity, which devolves upon all wholly independent forms, for receiving into the plant body a certain mineral surplus, of which calcium, received as the sulfate, nitrate, or phosphate, is a conspicuous example.

Whatever the disappointment may be that by this contribution, the question of distribution aside, we are no nearer than before to positive knowledge of the nature of this remarkable symbiosis, it is the presentation of an admirable hypothesis of the general function and distribution of mycorhiza, supported by a wealth of evidence which subsequent studies are far from likely to controvert. To the practical physiological ecologist the lists and detailed discussion of mycorhiza distribution will be found invaluable.

New data as to the mycorhizas of holosaprophytes and the structural degeneracy attendant upon this symbiosis are presented by MacDougal and Lloyd.[8] Species of Pterospora, Sarcodes, Hypopitys, and Monotropa were examined. Special emphasis is laid upon the profound morphological alterations of the host which ensue from such complete symbiosis as that which exists between the Monotropaceæ and the ectotropic fungi of its roots. In this family the shoots are to be regarded as physiologically insignificant in the economy of the plant, being purely reproductive in purpose and comparatively ineffective in that function. The roots, which reproduce the plant, serve as organs of storage, are the habitat of the fungus, the absorbing member of the symbiosis, and are the seat of the chief activities of the plant. Pterospora shows an interesting exception to the general tendency of shoot reduction in its development of a comparatively large branched aerial portion which is supplied with stomata.—J. G. COULTER.

ITEMS OF TAXONOMIC interest are as follows: In *Proc. Biol. Soc. Washington* (13 : 129–132. 1900) C. L. POLLARD has published eight new species belonging to Lupinus, Viola (2), Gentiana (3), Chrysopsis, and Solidago.—The species and hybrids of *Mentha*, a paper by ERNEST MALINVAUD, has been translated into English and published in *Journ. Bot.* 38 : 171–174. 1900. —A list of the angiosperms of Delagoa Bay, Africa, has just been published by HANS SCHINZ (Zürich) and Henri Junod (Delagoa Bay) in *Mém. de l'Herb. Boiss.* (no. 10. March 30, 1900.) No. 11 of the same series (issued April 30) is devoted to a continuation of *Species Hepaticarum*, by FRANZ STEPHANI, the genera *Hymenophytum* (4 spp.), *Pallavicinius* (22 spp., 5 new), *Symphyogyna* (39 spp., 14 new), and *Monoclea* (2 spp.) being included. No. 12 of the same series (issued April 30) contains an account (with 4 plates) of the European species of *Utricularia*, by FR. MEISTER, together with a

[8] MACDOUGAL, D. T., and LLOYD, E. F.: The roots and mycorhizas of some of the Monotropaceæ: Bull. N. Y. Bot. Garden 1: 419–428. 1900.

discussion of their anatomical and ecological features. No. 14 of the same series (issued May 30) contains an account (with 1 plate) of the Japanese Mutisiaceæ from the collection of Faurie, by A. FRANCHET. No. 15 of the series (issued May 30) contains an account of certain new or little known Chytridineæ, by E. DE WILDEMAN.— Notes on some type specimens of Myxomycetes in the New York State Museum is a useful paper by W. C. STURGIS, published in *Trans. Conn. Acad. Arts and Sci.* 10 : 463–490, *pls. 60, 61.* 1900.— F. E. LLOYD and L. M. UNDERWOOD (*Bull. Torr. Bot. Club.* 27 : 147–168. *pls. 2–4.* 1900) have published a review of the North American species of *Lycopodium*, recognizing 29 species, two of which are described as new.— P. A. RYDBERG (*ibid.* 169–189. *pls. 5, 6*) has begun a series of papers entitled "Studies on the Rocky Mountain Flora," the first one being devoted to the *lobatus*, *aureus*, *subnudus*, and *tomentosus* groups of *Senecio*, in which assemblage of forms he recognizes 30 species, 18 of which are described as new.—W. R. MAXON (*ibid.* 197–199) has described a new *Asplenium* from southern and Lower California.— S. C. STUNTZ (*ibid.* 202–211) has published a revision of the N. Am. species of the genus *Eleutera* (Neckera), recognizing 6 species, all with new names.—G. N. BEST (*ibid.* 221–236. *pls. 7, 8*) has published a revision of the N. Am. species of *Pseudoleskea*, recognizing 7 species, two of which are new, and 4 varieties, all of which are new.— E. P. BICKNELL (*ibid.* 237–246) has reached his seventh paper on *Sisyrinchium*, which deals with the species of British America. He recognizes 8 species, one of which is described as new, and there is no reason to question his statement that "there is no doubt that this number may be increased."—W. W. ROWLEE (*ibid.* 247–257. *pl. 9*) has published an account of the *longifolia* group of willows as displayed in North America. He recognizes 12 species, three of which are described as new, and 3 varieties, all of which are new.—AVEN NELSON (*ibid.* 258–274), in continuing his account of new plants from Wyoming, has described 23 new species and varieties.—J. K. SMALL (*ibid.* 275–281), in continuing his notes and descriptions of N. Am. plants, has described 11 new species.— FLORA W. PATTERSON (*ibid.* 282–286) has described 17 new species of fungi.—GEO. V. NASH (*Bull. N. Y. Bot. Garden*, 1 : 429–437. 1900) has described 11 new grasses from the southern states, and a new *Trisetum* from Michigan.—J. K. SMALL (*ibid.* 437–447) has published a revision of the genus *Bumelia* in North America, recognizing 13 species, five of which are described as new.— N. L. BRITTON (*ibid.* 447–449) has described 7 new species of *Crataegus*.—MRS. KATHARINE BRANDEGEE has published a second paper in the series on Cacteæ (*Zoe* 5 : 1–9. 1900), the first having appeared in *Erythea* (3 : 123. 1895). It contains critical remarks upon numerous species, and descriptions of one new species of Cereus and two of Mamillaria.— J. M. C.